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Management of spot blotch of barley through different dates of sowing and chemical and organic amendments

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ABSTRACT

Spot blotch caused by *Bipolaris sorokiniana* is one of the most serious diseases of barley in tropical areas where barley and wheat are grown. A field experiment was conducted at Regional Research Station Masodha, ANDUA&T, Kumarganj, Ayodhya, Uttar Pradesh during *Rabi* season. To evaluate the effect of different dates of sowing and chemical and organic amendments on spot blotch and consequently on seed quality of barley. The experiment was conducted during the *Rabi* season 2016-17 under hotspot area of spot blotch. RD-2794 was sown in a split plot manner with two dates of sowing.The experiment was performed in split plot design with three replications comprising two different dates of sowing, *i.e.* mid- November (D_1) and mid-December (D_2) in the main plot and chemical and organic amendments *viz.*, RDF (60N:30P:20K kg/ hectare) -T_1, FYM @ 5 t/h-T_2, T_1 + Mulch@ 6 t/h-T_3, T_1 + FYM @ 5t/hec + Mulch @ 6t/ hec.-T_4, T_4 + 2 spray of zinc sulphate @ 0.5 %-T_5, T_4 + 2 spray of KCl @0.5%-T_6 and T_5 + 2 spray of KCl @ 0.5 %-T_7 in the sub plot. Results revealed that minimum disease severity (46.9%) with maximum disease control (39.98%) and per cent seed infection (5.5%) were recorded in $D_1 \times T_7$. The interpretation of data revealed that there was highly positive and significant correlation (r=0.95) between disease severity and per cent seed infection. The maximum 1000-seed weight (43.41g) and yield (38.67 q/ha) with maximum yield gain (57.25%) was also recorded in $D_1 \times T_7$. The same treatment combination was also useful in maximizing the seed quality in terms of seed viability (98%), Germination (97%), seedling length (27.30cm) and vigour index-I (2648.153) when the freshly harvested seeds were tested in seed testing laboratory. Spot blotch is a serious disease of barley spreads primarily through infected seeds and reduced the yield up to 30%. The disease can be minimized by sowing the crop timely *i.e.* mid-November with recommended dose of fertilizers + FYM @ 5 t/ha+ Mulch@ 6 t/ha+ 2 spray of zinc sulphate @ 0.5 % + 2 spray of KCl @ 0.5 % at flag leaf and post anthesis stage which improves the seed quality.

Key words : *Barley, Spot blotch, PDI, Seed viability, yield, Management*

Introduction

Barley is one of the most widely grown cereal crop in the world after wheat, rice and maize. The barley based farming system exists in wide areas along the dry margins (200-300 mm annual rainfall) of cultivation. Barley is superior to wheat in some minerals and fiber contents. It contains water soluble fiber (β-glucons) and oil compound (tocotrinol) which are found to be effective in lowering cholesterol level of blood (Abdul *et al.*, 1973; Chaurasia *et al.*, 2000; Biswas and Srivastava, 2010; Wani *et al.*, 2018d). The crop is sown with minimum care and management under residual moisture. Proper land preparation, application of fertilizers, irrigation, optimum time of sowing, seed rate *etc*. are not usually practiced in raising this crop. One of the major biotic stresses dragging down barley yield in Gangetic plains is spot blotch caused by *Bipolaris sorokiniana* (teleomorph *Chochliobolus sativus*). It is a widespread pathogen of many crop plants, especially barley, and occurs throughout the world (Deepankar *et al*., 2007; Rather *et al*., 2022d). It is particularly aggressive under conditions of high relative humidity and temperature associated with imbalanced soil fertility. Yield losses are variable, but are significant in fields with low inputs especially under late sown conditions (Doyer, 1938; Shakeela *et al*., 2017; Mohiddin *et al.,* 2021; Rather *et al.,* 2022b). Nutrient stress is known to enhance the spot blotch severity (Abdul *et al*., 1973; Padder *et al*., 2015) which gets further disappointing under adverse environmental conditions (Goel *et al*., 2006; Dar *et al*., 2015; Gupta *et al*., 2017; Bano *et al*., 2018; Rather *et al.,* 2022c). Therefore, studies were undertaken to work out the role of environment accomplished by different dates of sowing) and nutrient amendments on the occurrence and intensity of spot blotch and consequently their effect on seed quality in barley at Regional Research Station, Masodha (ANDUAT), Ayodhya.

Materials and Methods

The experiment was conducted during the *Rabi* season 2016-17 under hotspot area of spot blotch at Regional Research Station, Masodha (ANDUAT, Kumarganj, Ayodhya). The barley cv. RD-2794 was sown in a split plot manner with two dates of sowing *viz*., mid-November (D_1) and mid-December (D_2) in the main plot and six strategies of nutrient application *viz.,* recommended dose of fertilizers (RDF) *i.e.,* 60N:30P:20K kg/h) -T_1, FYM @ 5t/h (at the time of land preparation)-T_2, T_1 + mulch@ 6 t/h (mulching after germination)-T_3, T_1 + FYM @ 5t/h + mulch @ 6t/h-T_4, T_4 + 2 spray of zinc sulphate @ 0.5 % (flag leaf and post anthesis stages)-T_5, T_4 + 2 spray of KCl @0.5% (flag leaf and post anthesis stages)-T_6 and T_5 + 2 spray of KCl @ 0.5 % (flag leaf and post anthesis stages)-T_7 along with three replications. The treated seeds were planted 20cm apart in a plot size of 1.2m × 8 m. The crop was raised as per agronomic practices. Disease was allowed to develop epiphytotically from natural inoculums.

For the assessment of disease severity, 10 plants from each plot were randomly selected and disease rating was done by taking the per cent blotched area on flag leaf (F) and flag-1 (F-1) leaf using the rating scale as: 0 = No infection, 1 = up to 10%, 2 = 11-20%, 3 = 21-30%, 4 = 31-40%, 5 = 41-50%, 6 = 51-60%, 7= 61-70%, 8 = 71-80%, and 9= > 80% (Hales, 1992). The disease score of each selected plants were recorded by using (double digit scale (Table A) based on per cent blighted area on the flag and one leaf just below. The maximum disease score of each genotype was recorded finally.

Disease severity was assessed by determining the number of lesions per cm^2. First and second value respectively represents percent blighted area on the top (flag) and second top leaf. Value 1, 2, 3, 4, 5, 6, 7, 8, and 9, respectively correspond to 10, 20, 30, 40, 50, 60, 70, 80, and 9: > 80% blighted area. The percent

Table A. Double digit scale, based on per cent blighted area on the flag leaf and one leaf just below (Kumar *et al*., 1998)

S. No.	Severity Top (flag) leaf	Rating Second top leaf	Disease response	Range
1.	0	0-1	Immune (I)	00-01
2.	1-2	2-4	Resistant (R)	12-24
3.	3-4	4-6	Moderately resistant (MR)	34-46
4.	5-6	6-8	Moderately susceptible (MS)	56-68
5.	7-8	8-9	Susceptible (S)	78-89
6.	9	9	Highly susceptible (HS)	99

disease intensity (PDI) and plant disease control (PDC) were calculated using equation I and II.

$$\text{PDI} = \frac{\text{sum of all numerical ratings}}{\text{Total number of observations taken} \times \text{highest disease score}} \times 100 \quad (1)$$

$$\text{PDC} = \frac{\text{PDI in control plants} - \text{PDI in treated plants}}{\text{PDI in control plants}} \times 100 \quad (2)$$

After harvesting and threshing the seeds were sampled separately and weighed which finally converted into yield q/h. Thousand seeds weight from each sample was taken with the help of digital balance. Seed was tested for viability using tetrazolium test (Khan *et al*., 2006). The Germination test was conducted using germination paper and the number of normal and abnormal seedlings and dead seeds were recorded on the 14th day of sowing (Lacicowa, 1982; Rather *et al*., 2022a;). On the day of final count 10 normal seedlings from each replication were taken randomly and seedling length was measured from tip of leaf to the tip of root excluding the seed. The seedling vigour index-I of each sample were calculated by multiplying the mean germination per cent by the mean seedling length (Lakon *et al*., 1949; Malecka *et al*., 2002). The per cent seed infection was estimated by standard blotter test method (Sharma and Duveiller, 2004; Rather *et al*., 2022e). The seeds were tested in the seed testing laboratory of NDUAT, Kumarganj, Ayodhya to assess the seed quality and percent seed infection.

Results and Discussion

Effects on disease incidence and severity

Findings of the present investigation presented in table 1a indicated that date of sowing and strategic nutritional application significantly (p≤0.05) influenced the spot blotch of barley. Mid December sowing (D_2) showed higher incidence of spot blotch (66.36%) that also resulted in higher seed infection (34.82%) compared to the lower incidence of spot botch (64.19%) and seed infection (27.50) in mid November sowing (D_1). Outcome of the experiment suggested that mid November sowing had greater potential of plant disease control (17.86%) compared to mid December sowing with plant disease control value of only 15.1%. The significance of date of sowing on leaf blight score was also reported through earlier workers (Bhat *et al*., 2011; Wani *et al*., 2018b; Bano *et al*., 2021; Padder *et al*., 2021) studied the effect of spot blotch disease severity and reported that early sown crop was less affected by spot blotch than late sown crop. Singh *et al*. (Wani *et al*., 2018a; Padder *et al*., 2022) also reported less spot blotch severity in early sown crop than late sown crop. The per cent seed infection depends on spot blotch disease severity and low disease severity was recorded

Table 1a. Individual effects of date of sowing and chemical and organic amendments on incidence and severity of spot blotch in barley sown

Treatment		PDI(%)	PDC(%)	Seed infection (%)
Date of sowing (D)				
D_1	Mid-November	64.19 (53.36)	17.86 (23.76)	27.50 (30.33)
D_2	Mid-December	66.36 (54.73)	15.1 (20.01)	34.82 (35.1)
	SEm±	00.117	0.219	0.373
	CD (5%)	0.768	1.437	1.067
Organic amendments and chemical sprays (T)				
T_1	Recommended dose of fertilizers (60N:30P:20K kg/h)	74.93 (59.94)	4.11 (11.416)	50.50 (45.28)
T_2	FYM @ 5 t/h (at the time of land preparation),	76.50 (60.99)	2.10 (5.904)	58.38 (49.86)
T_3	T_1 + Mulch@ 6 t/h (mulching after germination)	70.42 (57.04)	9.88 (18.21)	38.75 (38.46)
T_4	T_1 + FYM @ 5t/h + Mulch @ 6t/ h	67.01 (54.93)	14.25 (22.14)	31.50 (34.07)
T_5	T_4 + 2 spray of zinc sulphate @ 0.5 % (flag leaf and post anthesis stages)	64.59 (53.46)	17.35 (24.58)	21.00 (27.17)
T_6	T_4 + 2 spray of KCl @0.5% (flag leaf and post anthesis stages)	55.78 (48.3)	28.62 (32.33)	11.88 (19.99)
T_7	T_5 + 2 spray of KCl @ 0.5 % (flag leaf and post anthesis stages)	47.67 (43.65)	39.00 (38.63)	6.125 (14.17)
	SEm±	0.236	0.297	0.697
	CD (5%)	0.693	0.871	1.996

Data given in parentheses are angular transformed value in early sown crop plot as also reported earlier by (Bhat *et al*., 2017; Malik *et al.*, 2018; Bano *et al.,* 2022) wherein timely sown crop was less affected by spot blotch than late sown.

Data regarding the individual effects of nutritional amendments (Table 1a) clarified that FYM @ 5 t/h lead to the highest values of PDI (76.50%) as well as seed infection (58.38%) followed by RDF with PDI and seed infection values of 74.93 and 50.50%, respectively. However, treatment T_7 *i.e.*, T_5 + 2 spray of KCl @ 0.5 % (flag leaf and post anthesis stages) most effectively reduced the disease infection (PDI) as well as seed infection with absolute values of 47.67 and 6.125%, respectively followed by T_6 *i.e.*, T_4 + 2 spray of KCl @0.5% (flag leaf and post anthesis stages) with PDI and seed infection values of 55.78 and 11.88%, respectively. However, in contrast to leaf disease incidence or seed infection T_1 and T_2 showed lower values of PDC with their absolute value of 2.10 and 4.11%, respectively while as the maximum value of PDC (39.00) was recorded with T_7 followed by T_6 with calculated PDC value of 28.62 percent. Our finding corroborates the findings of Gupta *et al.,* 2017 who found that application of macro and micronutrients (N, P, K, Zn, S and B) plus seed treatment with carboxin + thiram and two foliar sprays of propiconazole resulted in the lowest mean value for grain infection (5%) (Shakeela *et al*., 2017) reported that percent seed infection with *B. sorokiniana* ranged from about 5 to 95% and infection levels of seeds from organically cultivated plots were about twice as high as those of seeds from plots receiving conventional treatments. In our findings it was recorded that per cent seed infection was less in organic and chemical amended plot (T_7) which reduced maximum disease severity which was in accordance with the findings Sharma *et al.*, 2006.

Data with regard to the interaction effects of date of sowing and strategic application of nutrients (Table 1b) on disease incidence and control indicated that $D_2 \times T_2$ gave highest PDI (78.14%) and seed infection (65.25%) followed by $D_2 \times T_1$ with PDI and seed infection values of 76.24 and 57.00%, respectively. $D_1 \times T_7$ and $D_2 \times T_7$ produced the least values of PDI (46.9 and 5.5%) as well as seed infection (48.43 and 6.75%), respectively. The highest PDC value (39.98%) was recorded with $D_1 \times T_7$ followed by $D_2 \times T_7$ (38.03%), $D_1 \times T_6$ (29.08%) and $D_2 \times T_6$ (28.16%) against the minimum PDC value recorded with $D_2 \times T_2$ (0.00%) followed in ascending order by $D_2 \times T_1$ (2.44%) and $D_1 \times T_2$ (4.2%).

Table 1b. Interaction effects of date of sowing and chemical and organic amendments on incidence and severity of spot blotch in barley sown

Treatment	PDI (%)	PDC (%)	% Seed infection
$D_1 \times T_1$	73.63 (59.08)	5.78 (13.9)	44.0 (41.53)
$D_1 \times T_2$	74.86 (59.88)	4.2 (11.81)	51.5 (45.84)
$D_1 \times T_3$	69.04 (56.17)	11.65 (19.94)	36.25 (36.99)
$D_1 \times T_4$	66.16 (54.41)	15.34 (23.04)	28.25 (32.05)
$D_1 \times T_5$	63.30 (52.694)	18.99 (25.82)	17.75 (24.88)
$D_1 \times T_6$	55.42 (948.09)	29.08 (32.62)	9.25 (17.64)
$D_1 \times T_7$	46.9(43.207)	39.98 (39.20)	5.5 (13.37)
$D_2 \times T_1$	76.24(60.80)	2.44 (8.93)	57.00(49.02)
$D_2 \times T_2$	78.14(62.10	0.00 (0.00)	65.25 (53.87)
$D_2 \times T_3$	71.81(57.91)	8.10 (16.48)	41.25 (39.94)
$D_2 \times T_4$	67.86(55.44)	13.16 (21.24	34.75 (36.09)
$D_2 \times T_5$	65.87(54.23)	15.71 (23.33	24.25 (29.47)
$D_2 \times T_6$	56.14(48.51)	28.16 (32.04)	14.0 (22.34)
$D_2 \times T_7$	48.43(44.08)	38.03 (38.06)	6.75 (14.97)
SEm±	0.186	0.261	0.986
CD (5%)	0.741	1.188	2.823

D_1-Mid-November, D_2- mid-December, T_1-Recommended dose of fertilizers (60N:30P:20K kg/hectare), T_2- FYM @ 5 t/hec (at the time of land preparation), T_3- T_1 + Mulch@ 6 t/hec (mulching after germination) , T_4- T_1 + FYM @ 5t/hec + Mulch @ 6t/ hec., T_5 - T_4 + 2 spray of zinc sulphate @ 0.5 % (flag leaf and post anthesis stages), T_6- T_4 + 2 spray of KCl @0.5% (flag leaf and post anthesis stages) – T_6 and T_7- T_5 + 2 spray of KCl @ 0.5 % (flag leaf and post anthesis stages). Data given in parentheses are in angular transformed

Findings of the present study corroborates with the findings of. (Mohiddin *et al*., 2017; Dar *et al*., 2018; Mohiddin *et al*., 2017) who reported that balanced application of N, P, K reduces disease severity by 15 to 22%. Application of KCl as well as $CaCl_2$ reduces spot blotch severity but the former caused 11% reduction than later. Findings of the present study regarding the date of sowing on leaf blight disease severity is in conformation to the findings of (Baba *et al.*, 2014; Padder *et al*., 2017). Biswas and Srivastava (2010) also studied the effect of time of sowing on spot blotch disease severity and reported that early sown crop was less affected by spot blotch than late sown crop. Moreover, also reported less spot blotch severity in early sown crop than late sown crop (Dar *et al.,* 2016). Our findings regarding per cent seed infection were in the range as reported by (Dar *et al.,* 2016). They reported that percent seed infection with *B. sorokiniana* ranged from about 5 to

95% and was highly dependent on the site, production system and variety. Thus both timely sowing and organic and chemical amendments reduces spot blotch severity which resulted in low per cent seed infection. The analyzed data reveals that there was highly positive and significant correlation between disease severity and per cent seed infection (r=0.95).

Effect on yield and yield attributing characters

Role of different sowing dates as well as organic and chemical nutrient amendments on yield and yield attributing characters were also worked out in connection with disease incidence and severity. Significant differences (p=.5) were observed for individual effects of sowing dates and different nutrient treatments (Table 2a). Mid November (D_1) sowing of barley showed higher test weight (34.09 g), and grain yield (31.13q/h) compared to mid December sowing (D_2) with a test weight and grain yield value of 32.03g and 29.36q/h, respectively.

The individual effects of different organic and inorganic nutrient amendments also showed significant variations (p=.5) with respect to 1000 seed weight as well as grain yield q/h (Table 2a). Treatment T_7 (T_5 + 2 spray of KCl @ 0.5 % (flag leaf and post anthesis stages) resulted in highest value of 1000-grain weight (42.85g) and yield (36.12q/h) followed by *T6* (T_4 + 2 spray of KCl @0.5% (flag leaf and post anthesis stages) and T_5 (T_4 + 2 spray of zinc sulphate @ 0.5 % (flag leaf and post anthesis stages) with absolute 1000 seed weight and grain yield values of 37.643g and 33.04q/h and 35.042g and 31.35q/h, respectively against the minimum value of 1000-seed weight (26.740g) and grain yield (25.46q/h) in T_2 (FYM @ 5 t/h (at the time of land preparation) followed by T_1 (Recommended dose of fertilizers (60N:30P:20K kg/h) with 1000-seed weight and grain yield value of 27.545g and 26.60q/h, respectively. Additionally, November (D_1) sowing showed higher gain yield (26.58%) than that of December sowing (D_2) (19.37%). Among the individual treatments of nutritional amendments T_7 i.e., T_5 + 2 spray of KCl @ 0.5 % (flag leaf and post anthesis stages) showed the highest yield gain of 46.89% trailed by T_6 and T_5 with yield gain values of 34.35 and 27.47 percent, respectively against the poorest yield gain (3.50%) recorded in T_2 followed by T_1 with an yield gain value of 8.15 percent.

The findings of the present investigation corroborates the findings of earlier researchers like (Dar *et al.,* 2015) reported reduction in 1000-seed weight under late sowing of wheat. Similarly, also reported that 1000-grain weight was higher in early planting date than those of late planting date (Dar *et al.,*

Table 2a. Individual effects of date of sowing and chemical and organic amendments on incidence and severity of spot blotch in barley sown

Treatment		1000 seed weight (g)	Yield (kg/plot)	Yield (q/h)	Yield gain (%)
Date of sowing (D)					
D_1	Mid-November	34.09	1.74	31.13	26.58(30.07)
D_2	Mid-December	32.03	1.65	29.36	19.37(23.48)
	SEm±	0.189	0.004	0.113	0.266
	CD (5%)	0.551	0.025	0.738	1.744
Organic amendments and chemical sprays (T)					
T_1	Recommended dose of fertilizers (60N:30P:20K kg/h)	27.545	1.49	26.60	8.15(16.04)
T_2	FYM @ 5 t/h (at the time of land preparation),	26.740	1.43	25.46	3.50(7.66)
T_3	T_1 + Mulch@ 6 t/h (mulching after germination)	29.340	1.61	28.78	17.04(24.27)
T_4	T_1 + FYM @ 5t/h + Mulch @ 6t/ h	32.255	1.70	30.36	23.44(28.88)
T_5	T_4 + 2 spray of zinc sulphate @ 0.5 % (flag leaf and post anthesis stages)	35.042	1.76	31.35	27.47(31.58)
T_6	T_4 + 2 spray of KCl @0.5% (flag leaf and post anthesis stages)	37.643	1.85	33.04	34.35(35.86)
T_7	T_5 + 2 spray of KCl @ 0.5 % (flag leaf and post anthesis stages)	42.853	2.04	36.12	46.89(43.14)
	SEm±	0.354	0.013	0.272	0.740
	CD (5%)	1.030	0.039	0.797	2.174

Data given in parentheses are in angular transformed

2015). Higher disease incidence was reported in late sown crop by (Sharma *et al*., 2006; Singh *et al.,* 2005) when they were studying the role of spot blotch in deteriorating the seed quality. In their study they found that the ear head infection resulted in brown discolouration of spikelets. Thousand seed weight of discoloured and black pointed grains was reduced over healthy looking seeds and ranged from 13.3 to 65.6 and 2.5 to 33.4%, respectively. Our finding on 1000-seed weight regarding various organic and chemical treatments corroborates the findings of (Singh *et al.*,1998) who reported that balanced application of N, P, K reduced disease severity by 15-22% and application of of KCl as well as $CaCl_2$ reduces spot blotch severity but the former caused 11% more reduction than later. They also reported that spot blotch disease reduced 1000-seed weight and it was ranged from 7.07 to 43.65% (Singh *et al.,* 2004).

In the present study (Table 2b), interaction effects of sowing date and nutritional amendments differed significantly (p=.5) wherein $D_1 \times T_7$ recorded highest value of 1000-seed weight (43.407g) as well as grain yield (38.667q/h) followed by $D_2 \times T_7$ with 1000-seed weight and grain yield of 42.300g and 33.571q/h, respectively. However, $D_2 \times T_2$ resulted in minimum weight of 1000-seeds (24.780g) as well as seed yield (24.595q/h) seconded by $D_2 \times T_1$ with absolute 1000-seed weight of 26.00g and grain yield of 25.637q/h. Looking into the yield gain percent of different interaction treatments clarified that $D_1 \times T_7$ was also instrumental in producing the highest yield gain (57.25%) followed by $D_2 \times T_7$ and $D_1 \times T_6$ with yield gain percent of 36.54 and 36.10, in that order which were also found at par with each other. $D_1 \times T_2$ remained as the minimum yield gain producing treatment with its absolute value of 7.0 percent.

In the present investigation, the findings of the interaction effect were in accordance with the findings of (Singh and Singh, 2006; Singh and Singh, 2007) in case of planting date and organic and chemical treatments, the findings of the present investigation was in accordance with the findings of (Sivanesan, 1987) and. (Sultana and Rashid, 2012) that has been discussed in the effect of organic and chemical treatments. Our finding in the present investigation corroborates with the earlier findings of (Wiewiora, 2006) who reported that early sown crop was less affected by spot blotch than late sown crop and resulted in higher yield. They also reported that yield was affected by date of sowing and higher yield was obtained from 15th November date of sowing. In the experiment found that the average yield loss due to spot blotch was about 17.36% (53).

The lower disease severity and higher seed yield

Table 2b. Interaction effects of date of sowing and chemical and organic amendments on incidence and severity of spot blotch in barley sown

Treatment	1000 seed weight	Yield kg/plot	Yield q/h	Yield gain (%)
$D_1 \times T_1$	29.090	1.543	27.560	12.06 (20.27)
$D_1 \times T_2$	28.700	1.474	26.315	7.0 (15.32)
$D_1 \times T_3$	29.570	1.649	29.446	19.74 (26.35)
$D_1 \times T_4$	33.360	1.722	30.744	25.01 (29.99)
$D_1 \times T_5$	35.667	1.776	31.708	28.93 (32.52)
$D_1 \times T_6$	38.850	1.874	33.470	36.1 (36.91)
$D_1 \times T_7$	43.407	2.165	38.667	57.25 (49.16)
$D_2 \times T_1$	26.000	1.436	25.637	4.24 (11.81)
$D_2 \times T_2$	24.780	1.377	24.595	0
$D_2 \times T_3$	29.110	1.575	28.119	14.35 (22.2)
$D_2 \times T_4$	31.150	1.678	29.970	21.87 (27.77)
$D_2 \times T_5$	34.417	1.735	30.988	26.01 (30.63)
$D_2 \times T_6$	36.437	1.826	32.613	32.61 (34.81)
$D_2 \times T_7$	42.300	1.913	33.571	36.54 (37.12)
SEm±	0.500	0.009	0.208	0.556
CD (5%)	1.457	0.033	0.768	1.971

D_1-Mid-November,D_2- mid-December, T_1-Recommended dose of fertilizers (60N:30P:20K kg/hectare) ,T_2- FYM @ 5 t/hec (at the time of land preparation),T_3- T_1 + Mulch@ 6 t/hec (mulching after germination) , T_4 - T_1 + FYM @ 5t/hec + Mulch @ 6t/ hec., T_5 - T_4 + 2 spray of zinc sulphate @ 0.5 % (flag leaf and post anthesis stages), T_6 - T_4 + 2 spray of KCl @0.5% (flag leaf and post anthesis stages) –T_6 and T_7- T_5 + 2 spray of KCl @ 0.5 % (flag leaf and post anthesis stages).Data given in parentheses are in angular transformed observed after the application of KCl compared to $CaCl_2$. (Zaidi *et al.*, 1994) determined the disease severity on spring barley and found that it was affected by the following cover treatment (no mulching, straw mulch and cover crops while working on avoidable yield losses of barley caused by *B. sorokiniana* reported that that the avoidable yield losses differed with different treatments and the maximum yield loss was estimated up to the tune of 41.24% while the maximum yield loss in this investigation was recorded up to the tune of 46.89%) (Singh and Singh, 2007).

Effect on seed quality parameters

Evaluation of seed quality attributes in relation to sowing date and other nutritional amendments suggested that both the factors individually had marked influence on different seed quality attributes (Table 3a). The sowing of barley seed in mid November (D_1) produced the seeds with higher viability (77%) as well as germination (74%) compared to the lower viability of seeds (71%) and germination (68%) obtained from the mid December sowing (D_2). By producing greater seedling length, mid November sowing (D_1) was also able to give better seedling vigour index (1,545.13) compared to a lesser value of seedling vigour index (1,351.33) of mid December sowing (D_2). (Zaidi *et al.*, 1994) reported that besides losses in yield, spot blotch causes seed discoloration, shriveled seeds and losses in seed viability while (Singh and Singh, 2007; Padder *et al.*, 2021) concluded that early sown crop was less affected by spot blotch than late sown crop. (Dar *et al.*, 2016) reported that during germination of wheat seeds the pathogen transmitted from seed to plant and caused germination failure, coleoptiles infection and root infection. That fungus can limit germination drastically, even to 25% and the diseased seed gives rise to diseased and week seedlings (Dar *et al.*, 2016).

Among the individual treatments of nutrient amendments T_7 i.e., T_5 + 2 spray of KCl @ 0.5 % (flag leaf and post anthesis stages) resulted in highest seeds viability (97%) and germination (95%) followed by T_6 i.e., T_4 + 2 spray of KCl @0.5% (flag leaf and post anthesis stages) and T_5 i.e., T_4 + 2 spray of zinc sulphate @ 0.5 % (flag leaf and post anthesis stages) with their seed viability and germination values of 90 and 87 percent and 83 and 79 percent, respectively. With the greater values of seedling length, T_7, T_6 and T_5 were also able to produce the seedlings with better vigour index and showed their absolute values of 2,579.83, 2,083.03 and 1,686.31, respectively. Among all, T_2 once again remained as minimum with respect to seedling length of 14.15 cm and seedling vigour index of 705.31 followed by *T1* with the absolute values of seedling length and

Table 3a. Individual effects of date of sowing and chemical and organic amendments on incidence and severity of spot blotch in barley sown

Treatment		Seed viability (%)	Seed germination (%)	Seedling length (cm)	Vigour index-I
Date of sowing (D)					
D_1	Mid-November	77(60)	74 (61)	19.89	1,545.13
D_2	Mid-December	71(56)	68 (56)	18.81	1,351.33
	SEm±	0.282	0.232	0.133	13.120
	CD (5%)	0.821	0.676	0.388	38.203
Organic amendments and chemical sprays (T)					
T_1	Recommended dose of fertilizers (60N:30P:20K kg/h)	57(46)	55(48)	15.05	822.67
T_2	FYM @ 5 t/h (at the time of land preparation),	54(43)	50(45)	14.15	705.31
T_3	T_1 + Mulch@ 6 t/h (mulching after germination)	65(52)	62(52)	16.34	1,014.50
T_4	T_1 + FYM @ 5t/h + Mulch @ 6t/ h	75(57)	71(57)	17.65	1,245.95
T_5	T_4 + 2 spray of zinc sulphate @ 0.5 % (flag leaf and post anthesis stages)	83(62)	79(62)	21.32	1,686.31
T_6	T_4 + 2 spray of KCl @0.5% (flag leaf and post anthesis stages)	90(68)	87(69)	23.92	2,083.03
T_7	T_5 + 2 spray of KCl @ 0.5 % (flag leaf and post anthesis stages)	97(75)	95(78)	27.01	2,579.83
	SEm±	0.527	0.434	0.249	24.545
	CD (5%)	1.536	1.265	0.725	71.471

Data given in parentheses are in angular transformed seedling vigour index of 15.05cm and 822.67, respectively.

In accordance with the present study, (Baba *et al.*, 2014;Padder *et al.*, 2017) reported that low percentage of germination was recorded in treatments where no organic seed treatment was done. While as (Baba *et al.*, 2014) reported increasing level of nitrogen from 60kg/ha to 120kg/ha meagerly increased germination percentage and vigour index in rice. However, some studies also reported that spot blotch disease severity increases with the increase of nitrogen level (Singh and Singh, 2006) that ultimately reduced the seed quality (Padder *et al.*, 2017). The balanced application of N, P, and K reduced disease severity by 15-22%. Application of KCl as well as $CaCl_2$ reduced spot blotch severity, but the former caused 11% greater reduction than the later (). The integrated nutrient management practices enhanced seed quality and germination percent, and reduced the amount of dormant seeds (Sharma *et al.*, 2006; Singh *et al.*, 2005).

The interaction effect between the two different date of sowing and nutritional (organic and chemical) amendments (Table 3b) differed significantly (p=.5) for seed viability as well as germination percent but there was no any marked variation on seedling length and vigour index. The maximum seed viability (98%) and germination (97%) were recorded in seed lots obtained from plot $D_1 \times T_7$ (crop sown during mid-November with recommended dose of fertilizers +FYM @ 5 t/ha+ Mulch@ 6 t/ha+2 spray of zinc sulphate @ 0.5 % + 2 spray of KCl @ 0.5 % at flag leaf and post anthesis stage) while minimum seed viability (49%) and germination (43%) were recorded in $D_2 \times T_2$ (crop sown during mid-December with application of FYM @ 5 t/ha).

Our findings in the present investigation showed that timely sown crop had less disease severity as compared to late sown as also reported earlier by (Padder *et al.*, 2017) while reported that balanced application of N, P, K reduces disease severity by 15 to 22% (Shakeela *et al.*, 2017). Application of KCl as well as $CaCl_2$ reduces spot blotch severity but the former caused 11% reduction than later. Our findings regarding the disease severity and per cent seed infection and its effect on seed quality corroborates the findings of (Shakeela *et al.*, 2017; Dar *et al.*, 2016). The losses in viability and germination were in the range of 57-70 and 90-100% in discolored seeds and 45 to 47% in black point infected seeds as compared to healthy seeds (Shakeela *et al.*, 2017; Hussain *et al.*, 2021). Other researchers also reported that during

Table 3b. Interaction effects of date of sowing and chemical and organic amendments on incidence and severity of spot blotch in barley sown

Treatment	Seed viability %	Seed germination %	Seedling length (cm)	Vigour index-I
$D_1 \times T_1$	61(48)	58(50)	15.72	911.98
$D_1 \times T_2$	58(47)	56(48)	14.9	833.97
$D_1 \times T_3$	67(53)	65(54)	16.45	1,070.6
$D_1 \times T_4$	77(58)	73(59)	18.2	1,070.6
$D_1 \times T_5$	84(63)	83(66)	21.9	1,817.92
$D_1 \times T_6$	91(70)	89(71)	24.77	2,204.48
$D_1 \times T_7$	98(77)	97(80)	27.30	2,648.15
$D_2 \times T_1$	53(43)	51(46)	14.38	733.35
$D_2 \times T_2$	49(40)	43(41)	13.40	576.66
$D_2 \times T_3$	63(50)	59(50)	16.23	958.40
$D_2 \times T_4$	72(56)	68(56)	17.1	1,163.08
$D_2 \times T_5$	81(61)	75(60)	20.73	1,554.7
$D_2 \times T_6$	88(66)	85(67)	23.07	1,961.58
$D_2 \times T_7$	95(73)	94(76)	26.72	2,511.50
SEm±	0.746	0.614	0.352	34.712
CD (5%)	2.172	1.788	NS	NS

D_1-Mid-November,D_2- mid-December, T_1-Recommended dose of fertilizers (60N:30P:20K kg/hectare) ,T_2- FYM @ 5 t/hec (at the time of land preparation),T_3- T_1 + Mulch@ 6 t/hec (mulching after germination) , T_4- T_1 + FYM @ 5t/hec + Mulch @ 6t/ hec., T_5 - T_4 + 2 spray of zinc sulphate @ 0.5 % (flag leaf and post anthesis stages), T_6- T_4 + 2 spray of KCl @0.5% (flag leaf and post anthesis stages) –T_6 and T_7- T_5 + 2 spray of KCl @ 0.5 % (flag leaf and post anthesis stages).Data given in parentheses are in angular transformed

Treatment	PDI (%)	% Seed infection	Seed viability (%)	SVI	1000-seed weight	Yield (q/h)
$D_1 \times T_1$	73.63	44.00	61	911	29.090	27.560
$D_1 \times T_2$	74.86	51.50	58	833	28.700	26.315
$D_1 \times T_3$	69.04	36.25	67	1070	29.570	29.446
$D_1 \times T_4$	66.16	28.25	77	1070	33.360	30.744
$D_1 \times T_5$	63.30	17.75	84	1817	35.667	31.708
$D_1 \times T_6$	55.42	9.25	91	2204	38.850	33.470
$D_1 \times T_7$	46.90	5.50	98	2648	43.407	38.667
$D_2 \times T_1$	76.24	57.00	53	733	26.000	25.637
$D_2 \times T_2$	78.14	65.25	49	576	24.780	24.595
$D_2 \times T_3$	71.81	41.25	63	958	29.110	28.119
$D_2 \times T_4$	67.86	34.75	72	1163	31.150	29.970
$D_2 \times T_5$	65.87	24.25	81	1554	34.417	30.988
$D_2 \times T_6$	56.14	14.0	88	1961	36.437	32.613
$D_2 \times T_7$	48.43	6.75	95	2511	42.300	33.571

germination of wheat seeds the pathogen transmitted from seed to plant that lead to germination failure, coleoptile infection and root infection. Pearson's correlation coefficient analysis of the data further revealed that there were significant and negative correlation of percent disease incidence with seed viability (r = -0.96), SVI (r = -0.98), 1000-seed weight (r = -0.98) and seed yield (r = -0.95) (5,58).

Conclusion

Spot blotch is a serious disease of barley, spreads primarily through infected seeds and reduced the yield up to 30%. The disease can be minimized by sowing the crop timely, *i.e.* mid-November with recommended dose of fertilizers + FYM @ 5 t/ha+ Mulch@ 6 t/ha+ 2 spray of zinc sulphate @ 0.5 % + 2 spray of KCl @ 0.5 % at flag leaf and post anthesis stage which improves the seed quality.

Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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